CLAIMS

We claim:

1. A time-of-flight mass spectrometer, comprising:

an ion source that generates ions;

an ion extractor, fluidly coupled to said ion source, that extracts said ions from said ion source;

an ion detector, fluidly coupled to said ion source, that detects said ions;

a timing controller, in electronic communication with said ion source and said ion extractor, that controls the time of activation of said ion source and that activates said ion extractor according to a predetermined sequence;

a data acquisition system that comprises an ADC and that acquires data from said ion detector; and

a data processing system that receives from said data acquisition system transient regions from said ADC exceeding a predefined single ion threshold level.

2. A time-of-flight mass spectrometer, comprising:

an ion source that generates ions;

an ion extractor, fluidly coupled to said ion source, that extracts said ions from said ion source;

an ion detector, fluidly coupled to said ion source, that detects said ions;

a timing controller, in electronic communication with said ion source and said ion extractor, that controls the time of activation of said ion source and that activates said ion extractor according to a predetermined sequence;

a data acquisition system that comprises a multi-channel TDC and that acquires data from said ion detector such that an ion peak triggers a combination of TDC channels that is characteristic for the height of said ion peak; and

a data processing system that receives said data from said data acquisition system and estimates said peak height from said data.

3. The time-of-flight mass spectrometer of Claims 1 or 2 wherein said ion detector comprises a multi-anode detector.

4. The time-of-flight mass spectrometer of Claims 1 or 2 wherein said ion detector comprises:

a first multi-channel plate;

a second multi-channel plate behind said first multi-channel plate wherein said second multi-channel plate is operated in a linear mode; and,

a CuBe mesh behind said second multi-channel plate.

5. The time-of-flight mass spectrometer of Claim 4 wherein the front surface of said first multi-channel plate is covered with a thin semiconducting film that is reverse biased.

6. The time-of-flight mass spectrometer of Claim 5 wherein said film is a nitride film doped with alkali.

7. The time-of-flight mass spectrometer of Claim 5 wherein said film is GaN doped with lithium.

8. The time-of-flight mass spectrometer of Claim 5 wherein said film further comprises graded strained superlattice layers of GaN and GaAlN.

9. The time-of-flight mass spectrometer of Claim 4 further comprising a converter plate covered with a thin semiconducting film.

10. The time-of-flight mass spectrometer of Claim 9 wherein said film is a nitride film doped with alkali.

11. The time-of-flight mass spectrometer of Claim 9 wherein said film is GaN doped with lithium.

12. The time-of-flight mass spectrometer of Claim 9 wherein said film further comprises graded strained superlattice layers of GaN and GaAlN.

13. The time-of-flight mass spectrometer of Claim 4 further comprising a third multi-channel plate operated in linear mode and situated between said second multi-channel plate and said CuBe mesh.

14. The time-of-flight mass spectrometer of Claims 1 or 2 wherein said ion detector comprises analog detector voltage output digitization circuitry.

15. The time-of-flight mass spectrometer of Claim 14 wherein said analog detector voltage output digitization circuitry comprises Wilkinson ADC fast rundown circuitry.

16. A method of processing transient data from fast processes using a time-of-flight mass spectrometer, comprising:

generating ions in an ion source;

extracting said ions according to a predetermined sequence to produce extracted ions;

separating said extracted ions;

detecting said extracted ions with an ion detector to produce a transient;

acquiring said transient with a data acquisition system; and,

transferring to a data processing unit only those regions of said transient that exceed a predefined threshold.

17. The method of Claim 16, further comprising the steps of:

transferring position flags on said regions to said data processing unit;

analyzing abundances of said ions from said regions and corresponding said position flags; and,

analyzing the temporal profile of said fast processes with the time of activation of said extracting step.

18. A method of processing transient data from fast processes using a time-of-flight mass spectrometer, comprising:

generating ions in an ion source;

extracting said ions according to a predetermined sequence to produce extracted ions;

separating said extracted ions;

detecting said extracted ions with an ion detector to produce a transient;

splitting said transient into a plurality of channels;

triggering TDC measurements in each channel of said plurality of channels wherein said triggering occurs at a different signal height for each channel of said plurality of channels;

transferring timing signals from said triggering step to a data processing unit; and,

estimating a signal height and pulse shape by determining which channels were triggered in said triggering step.

19. The method of Claim 18, further comprising the steps of:

analyzing abundances of said ions from said estimated signal height; and

analyzing a temporal profile of said fast processes with the time of activation of said extracting step.

20. The method of Claim 18 further comprising the step of applying a different amplification to each channel of said plurality of channels.

21. The method of Claim 18 further comprising the step of applying a different attenuation to each channel of said plurality of channels.

22. The method of Claim 18 further comprising the step of applying a different discriminator level to each channel of said plurality of channels.

23. The method of Claim 18 wherein said detecting step further comprises detecting said ions with a multi-anode ion detector to resolve non-linearities in high ion multiplicity peaks.

24. A method for determining the number, time of arrival, and impact position of a plurality of ions arriving at a detector surface, comprising:

providing a multi-channel plate that produces an electron cloud in response to receiving an impinging ion;

defocusing said electron cloud onto a pixelated anode array;

measuring the fractions of said electron cloud received by nearest neighbor electrodes in said anode array; and,

centroiding the electron charge fraction appearing simultaneously on nearest neighbor anodes in said anode array to determine the number of ions impinging said detector surface, the time of arrival of each said impinging ion, and the spatial location at which each said impinging ion collided with said detector surface.

25. The method of Claim 24 wherein said pixelated array is an array of 64 anodes.

26. The method of Claim 24 wherein said pixelated array is an array of 256 anodes.

27. The method of Claim 24 further comprising the step of providing a meander delay line in front of said pixelated array.

28. A time-of-flight mass spectrometer, comprising:

an ion source that generates ions;

an ion extractor, fluidly coupled to said ion source, that extracts said ions from said ion source;

an ion detector, fluidly coupled to said ion source, that detects said ions;

a timing controller, in electronic communication with said ion source and said ion extractor, that controls the time of activation of said ion source and that activates said ion extractor according to a predetermined sequence; and,

a data acquisition system that comprises an ADC and a TDC and that acquires data from said ion detector wherein said TDC detects an ion peak having a transient from said ion detector and causes said ADC to record said transient.

29. A time-of-flight mass spectrometer, comprising:

an ion source that generates ions;

an ion extractor, fluidly coupled to said ion source, that extracts said ions from said ion source;

an ion detector, fluidly coupled to said ion source, that detects said ions;

a timing controller, in electronic communication with said ion source and said ion extractor, that controls the time of activation of said ion source and that activates said ion extractor according to a predetermined sequence; and,

a data acquisition system that comprises an ADC and a TDC and that acquires data from said ion detector wherein said TDC and said ADC operate in parallel with said ADC resolving high ion multiplicities from said ion detector and said TDC increasing the dynamic range of said ion detector.

30. A method for detecting the time of arrival of an ion signal in a time-of-flight mass spectrometer, comprising:

serializing a known parallel data word into a serial data stream;

modulating said serial data stream with said ion signal, thereby creating a modulated serial data stream; and,

deserializing said modulated serial data stream to determine said time of arrival.